Application of Satellite Data to Fire & Aerosol Monitoring at the NOAA's Satellite and Information Service

by

Donna McNamara[1], George Stephens[1], Shobha Kondragunta[2], Ana Prados[2], Mark Ruminski[1], and Ken Knapp[3]

[1] NOAA/NESDIS/OSDPD/Satellite Services Division
[2] NOAA/NESDIS/Office of Research and Applications
[3] NOAA/NESDIS/National Climatic Data Center

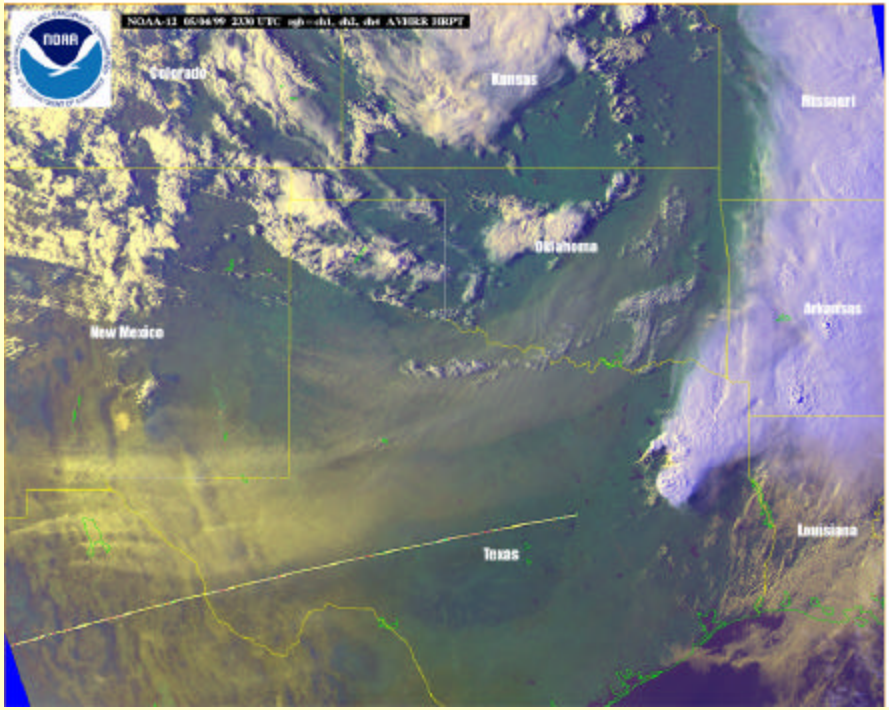
NESDIS Provides Satellite Applications to Assist Your Air Quality Programs

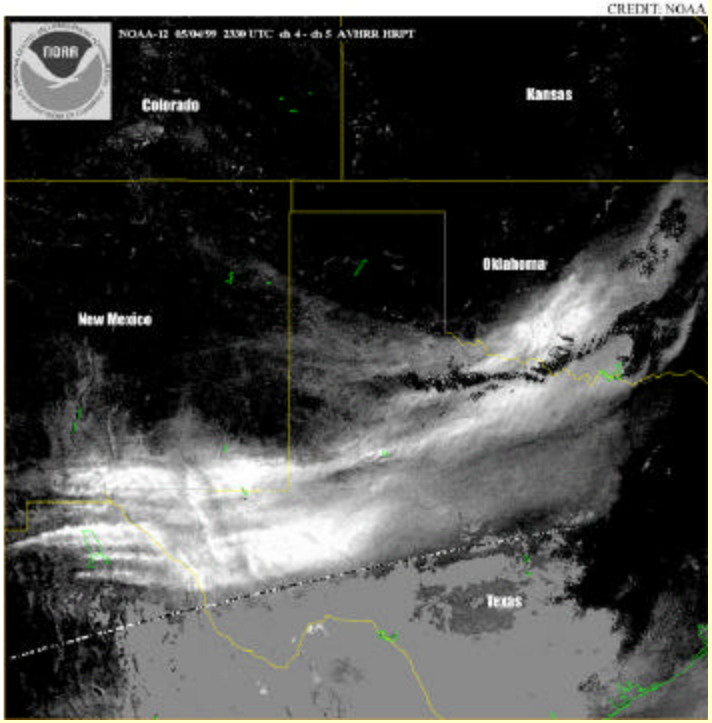
- Operational Significant Events Imagery (OSEI)
  - Dust
  - Smoke
- Hazard Mapping System (HMS) Fire & Smoke
  - Automated fire detection algorithms
  - Analyst quality controlled product
  - HYSPLIT smoke trajectories
- GOES Aerosol and Smoke Product (GASP)

Operational Significant Events Imagery (OSEI) Dust Imagery

Two images of airborne dust streaming off portions of southern New Mexico and Mexico, over northwestern Texas and central Oklahoma and into the circulation pattern of a storm system centered in eastern Kansas. In the left image, dust appears as a yellowish-brown haze. The right image was created using the "split-window" channel differencing technique which highlights clouds of airborne silicates in imagery. Dust in this image appears in varying shades of gray.

CREDIT: NOAA



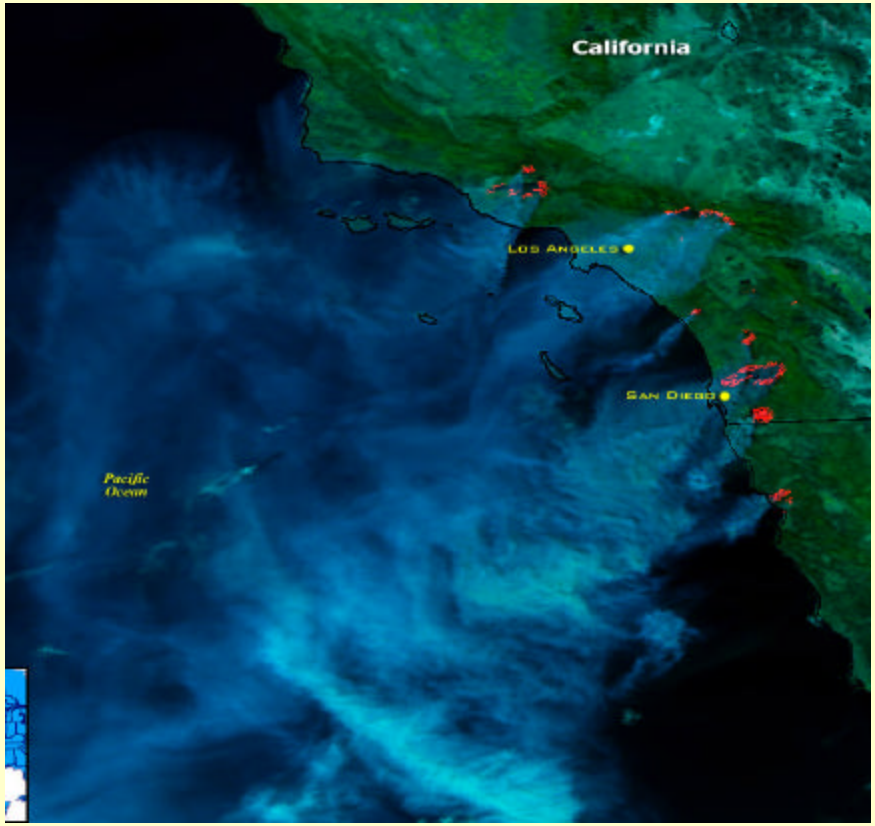


NOAA-16 Advanced Very High Resolution Radiometer image, May 15, 1999. Red is channel 1, green is channel 2, blue is channel 4. Dust appears as a yellowish-brown haze.

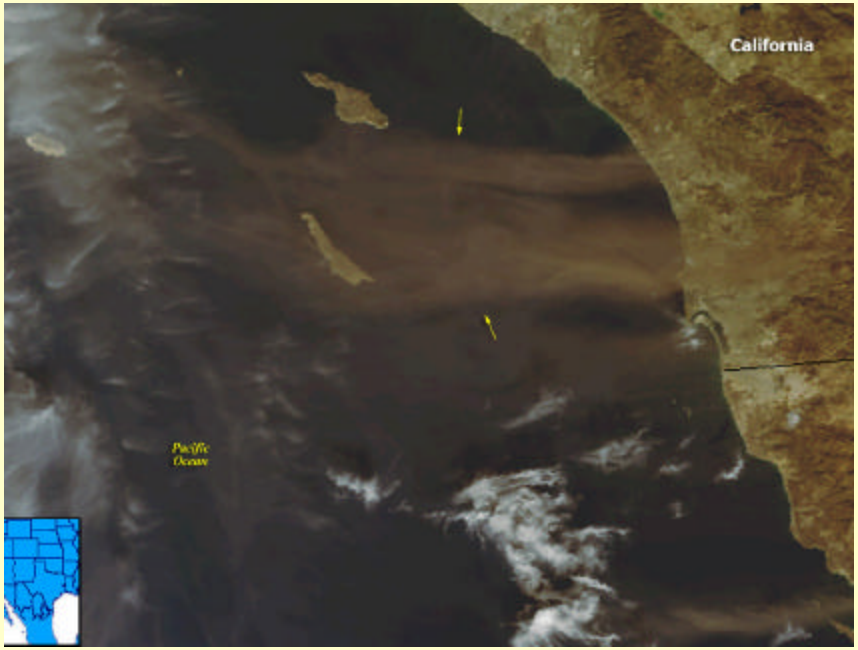
Same image, but using "split-window" (channel 4-5), enhancing the airborne dust.

OSEI – Fire & Smoke Imagery

Examples from devastating California fires, Oct & Nov 2003



NOAA-16 Advanced Very High Resolution Radiometer image, Oct. 26, 2003. Red is channel 3, showing fires; green is channel 2, showing vegetation and burn scars; blue is channel 1, showing smoke.



Moderate Resolution Imaging Spectroradiometer (MODIS) Image from NASA's Terra satellite, Nov. 27, 2003, shows dust and ash from burned areas blowing west over the Pacific Ocean. Burned areas subsequently were the source of deadly mudslides. Red is channel 1, blue channel 4, green channel 3.

OSEI – Long Range Transport

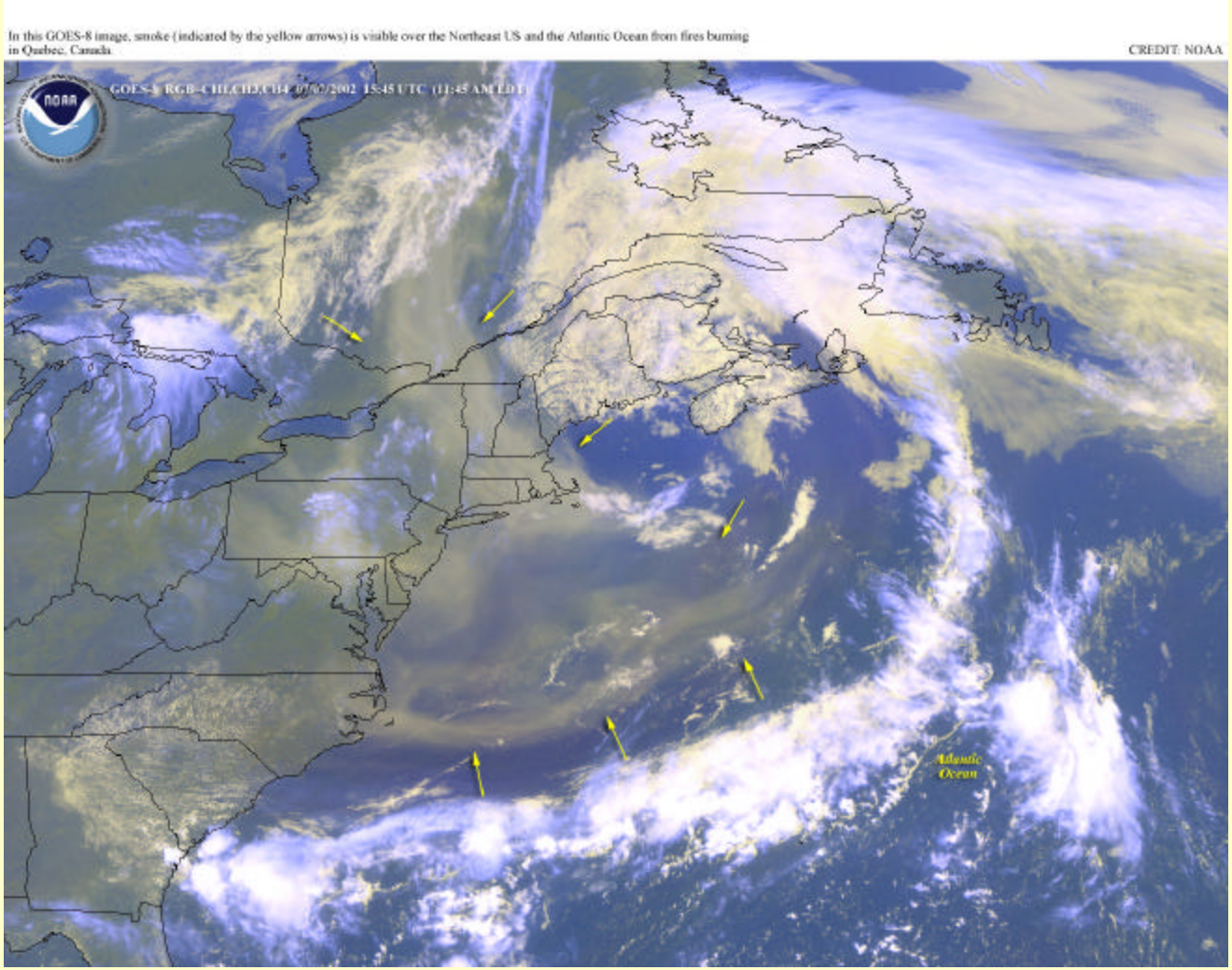
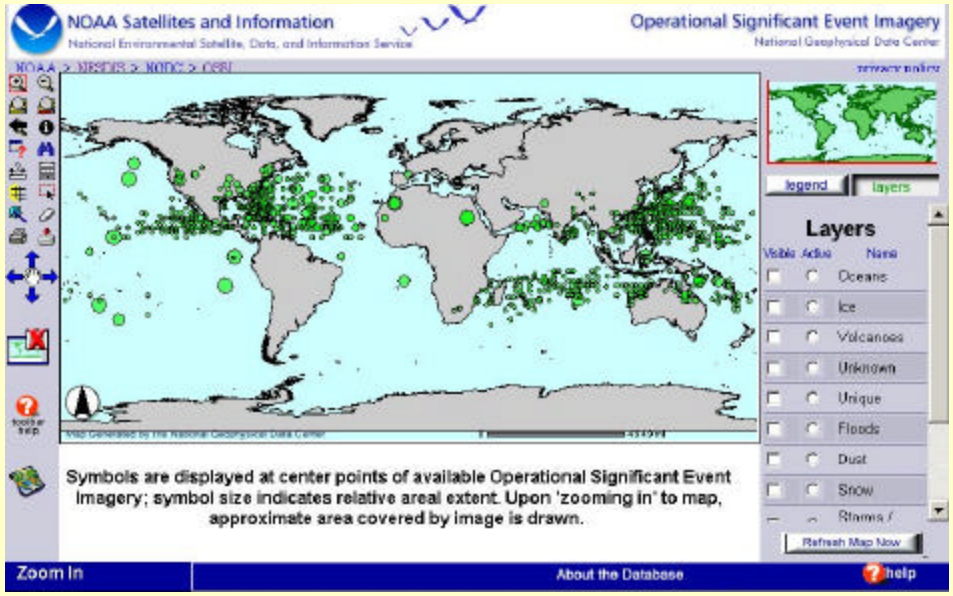


Image from GOES-8, Jul. 7, 2002, RGB=ch1, ch3, ch4, 15:45 GMT, Smoke (yellow arrows) visible over NE US & Atlantic Ocean from fires burning in Quebec CN.

OSEI Data Availability

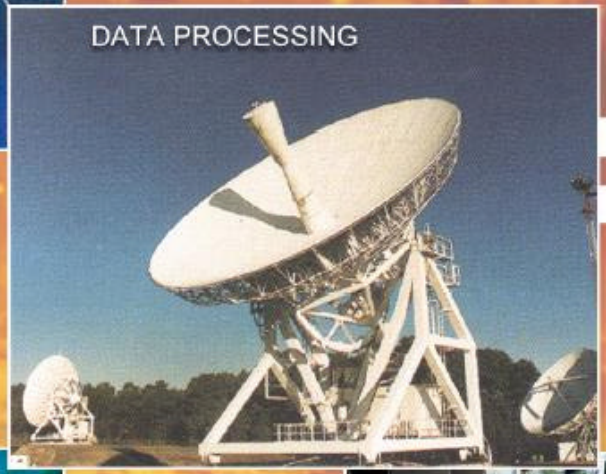
- http://www.osei.noaa.gov
  - High and low resolution jpg's
  - GeoTiff format (.tif), for use in GIS
  - Subscription service available
- New geographic and text archive search courtesy of NGDC [1]
  http://map.ngdc.noaa.gov/osei_intro.html



1. NOAA/NESDIS/National Geophysical Data Center, Ted Habermann project lead.

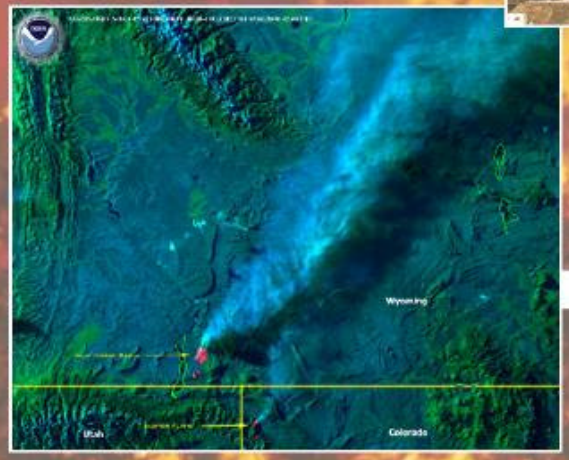
Hazard Mapping System Fire & Smoke Product

DATA PROCESSING



AUTOMATED
FIRE DETECTION
PRODUCTS

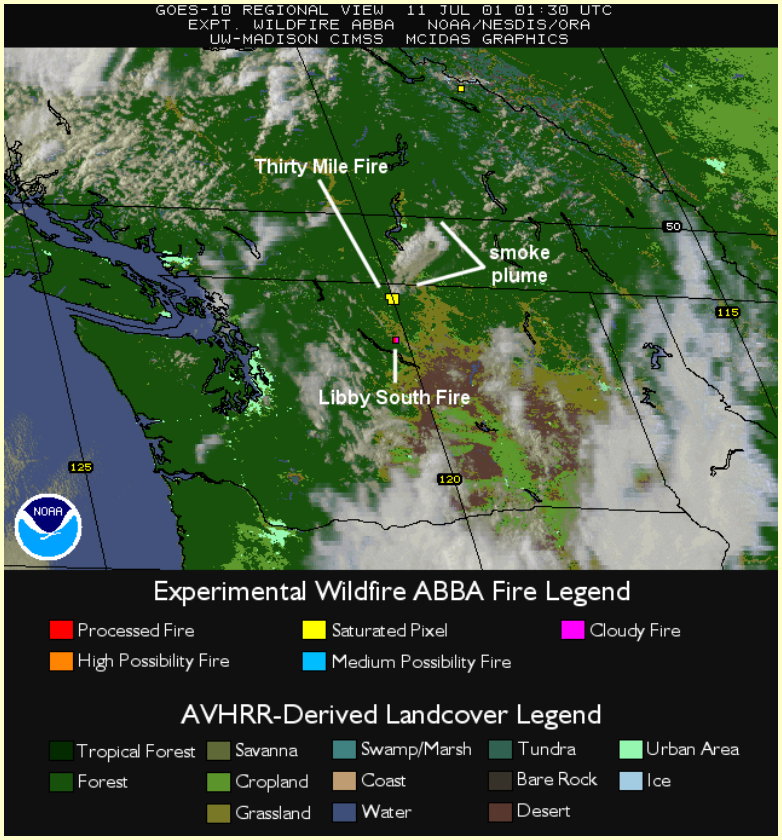
IMAGERY



USERS

ANALYST
INTEGRATED
PRODUCTS

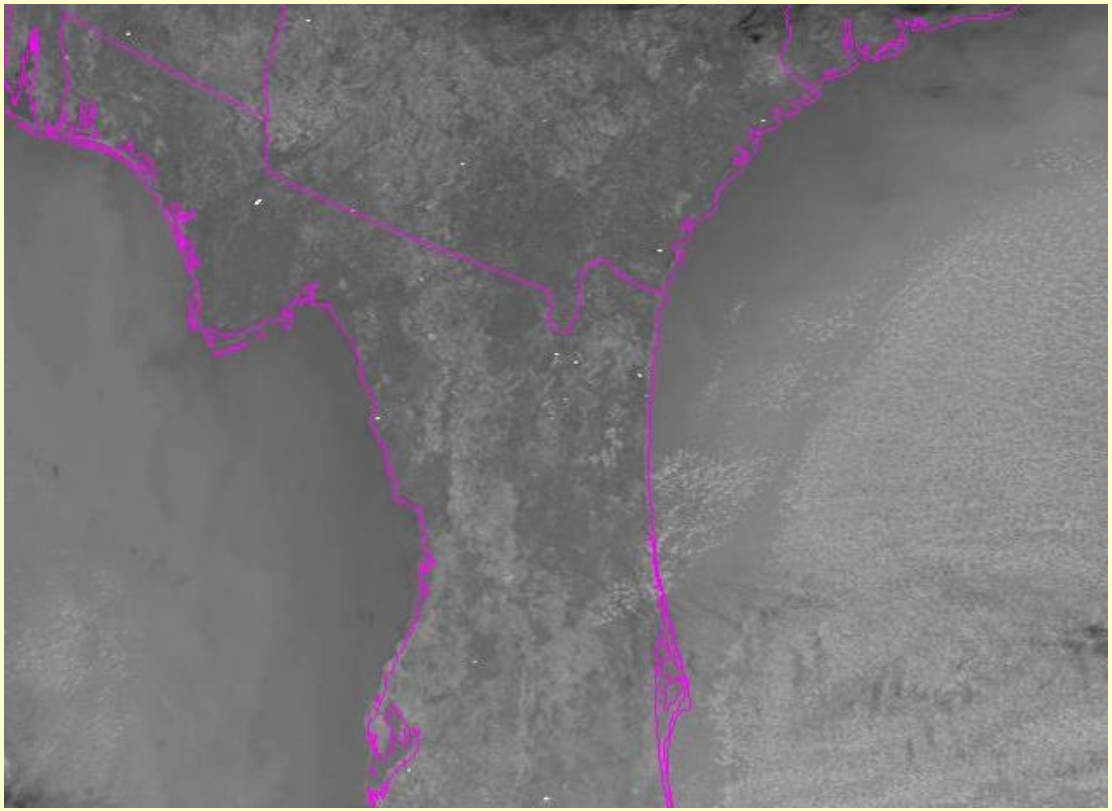
Input Layer – WF-ABBA from GOES



- Running Wildfire Automated Biomass Burning Algorithm (WF-ABBA) developed by Dr. Elaine Prins[1].
- Satellite analysts also rely heavily on images from Geostationary satellites.
- 15-minute image repeat cycle allows for rapid detection of hot spots and smoke plumes; animation.
- The GOES field of view at nadir is large (4x4 km), but the minimum detectable fire size at the sub-satellite point (smoldering at 450K) is approximately .002 km^2.

1. Dr. Elaine Prins, NOAA/NESDIS Office of Research and Applications/Cooperative Institute for Meteorological Satellite Studies (CIMSS) at the Univ. of Wisconsin. Chris Schmidt chief programmer.

Input Layer – FIMMA from AVHRR



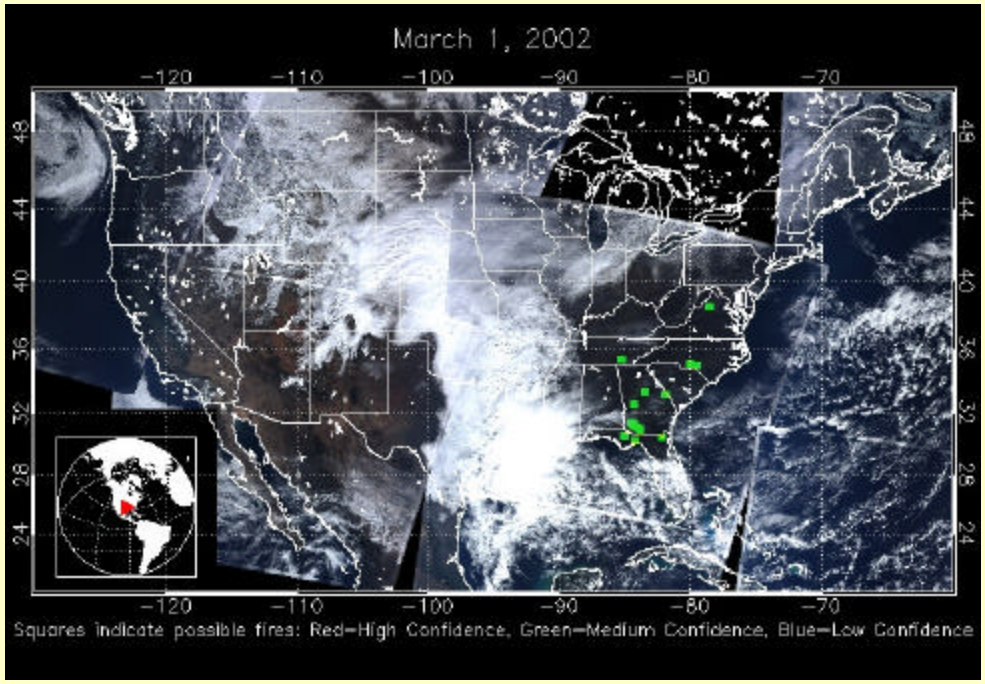
NOAA-16 High Resolution Picture Transmission (HRPT) image from the Advanced Very High Resolution Radiometer (AVHRR) instrument, Jan 7, 2004, 1849 GMT, channel 3. Hot spots show up as white.

- Running Fire Identification Mapping and Monitoring Algorithm, converted to contextual algorithm.
- Satellite analysts also view the HRPT (High Resolution Picture Transmission) data from Advanced Very High Resolution Radiometer instrument on polar-orbiting satellites NOAA-15, 16 & 17.
- First step in FIMMA is to pass data through navigation correction software. When ground points found, geolocation accuracy approaches 1 km.
- Field of view at nadir is 1.1 km^2.

1. FIMMA originally developed by Dr. Ivan Csiszar, formerly with the Cooperative Institute for Research in the Atmosphere at the NOAA/NESDIS Office of Research and Applications; currently with Univ. of Maryland. Conversion to contextual algorithm, based on MODIS algorithm, by Yi Song (RS Info. Systems).

Input Layer – MODIS

- Satellite Services Division receives Moderate Resolution Imaging Spectroradiometer (MODIS) imagery and fire products from NOAA's MODIS Near Real Time Processing System, run by it's sister division – the Information Processing Division [1].
- The MODIS instrument flies onboard the NASA TERRA and AQUA satellites, and the fire algorithm was developed by the MODIS Fire and Thermal Anomalies team [2].



• Field of view at nadir is 1 km^2 for thermal channels.

1. Gene Legg, NOAA/NESDIS/OSDPD/IPD; Paul Haggerty and K. Spreitzer, STC

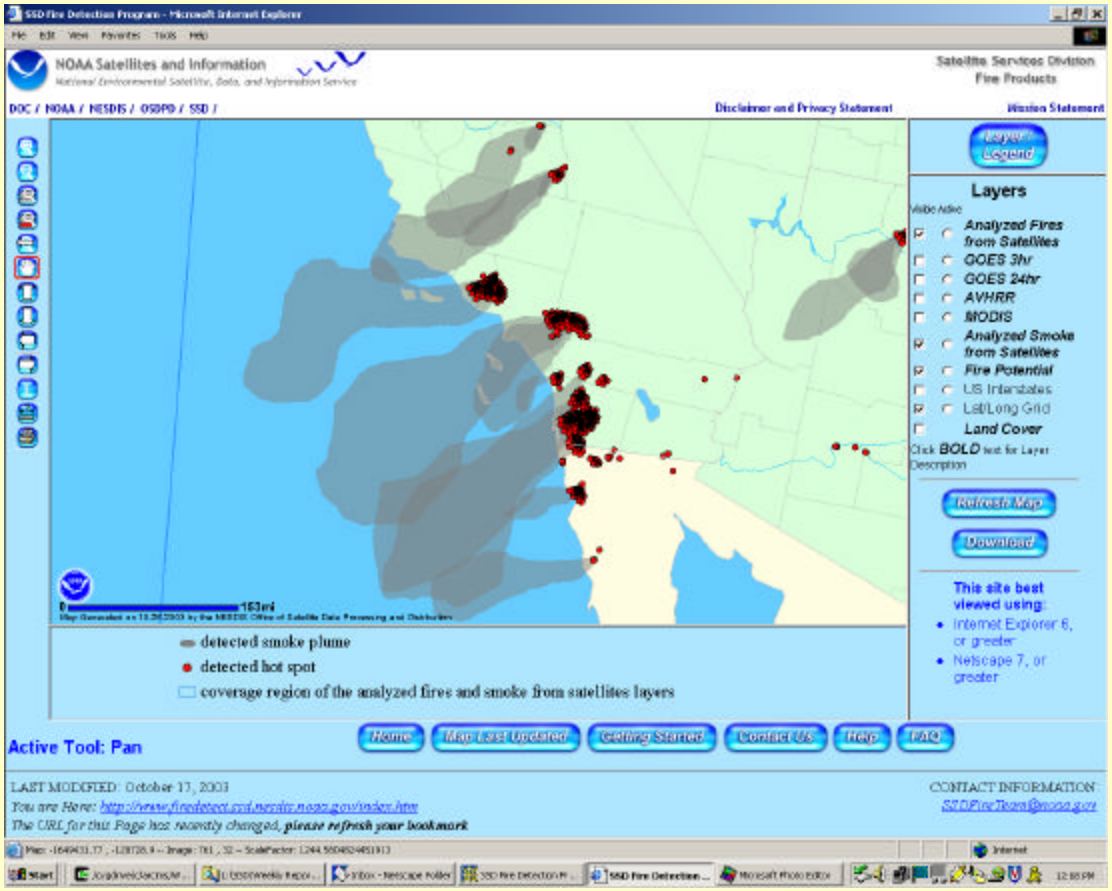
2. Dr. Christopher Justice PI, http://modis-fire.gsfc.nasa.gov/

Data Integration:
Hazard Mapping System (HMS)

Result – highly accurate, strategic view of hot spots and smoke in all 50 US states.

- The HMS is an interactive processing system that allows trained satellite analysts from SSD's Satellite Analysis Branch to integrate data from various automated fire detection algorithms and imagery.
- Shift runs 1-11 pm Eastern time.
  - (301)783-8444
- Suspicious detects from automated layers are deleted. Additional detects seen on imagery are added.
- Smoke is manually depicted from visible imagery.
- Daily products available in jpg, ASCII, and GIS shape file formats.

Web-GIS Fire Page

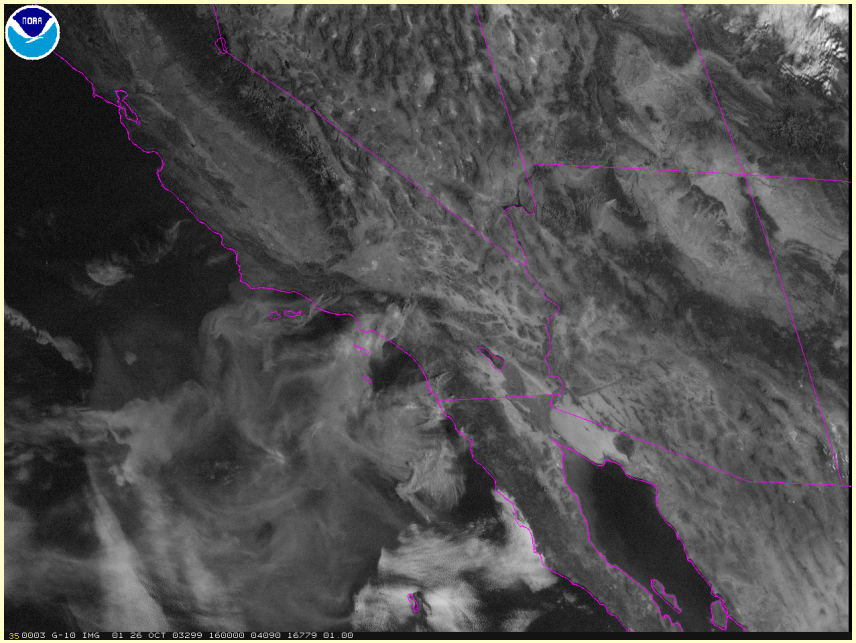


- Map server gives users access to layer updates in near real time, as well quality controlled HMS product from the analyst.
- Ancillary layers available: state & county outlines, interstates, lakes & rivers, land cover[1], fire potential[2] + more to come.
- Layers can be easily brought into your GIS systems.

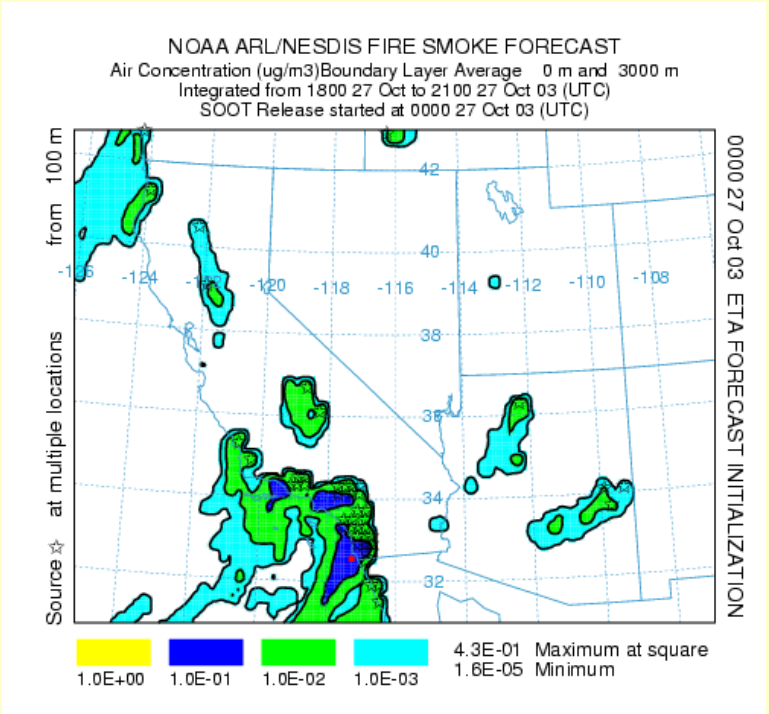
Links: http://firedetect.noaa.gov
http://www.ssd.noaa.gov/PS/FIRE/hms.html
http://gp16.wwb.noaa.gov/FIRE/fire.html

1. Boston University MODIS Land Cover project, Dr. Mark Friedl and John Hodges.
2. NOAA/NWS/Storm Prediction Center, Phil Bothwell & Gregg Grosshans.

Smoke Trajectories – HYSPLIT



GOES-10 satellite loop from Oct 27, 2003

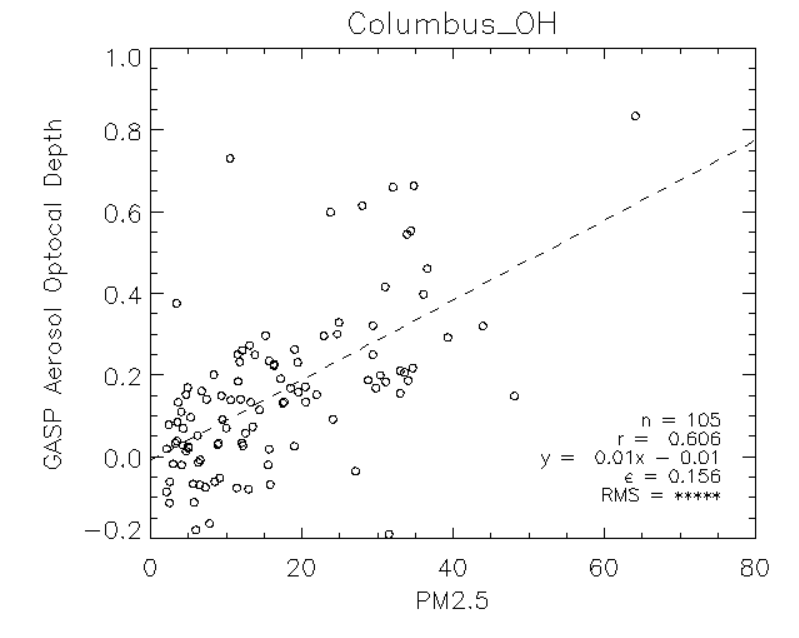


Analysts select fire points which are producing smoke as observed on satellite imagery. The coordinates of these points are input to the HYbrid Single-Particle Lagrangian Integrated Trajectory (HYSPLIT) model, run by NOAA/ARL[1]. The smoke forecast that corresponds with the satellite depiction of smoke is shown on the right.
http://www.arl.noaa.gov/smoke/forecast.html

1. NOAA/Air Resources Lab, Roland Draxler.

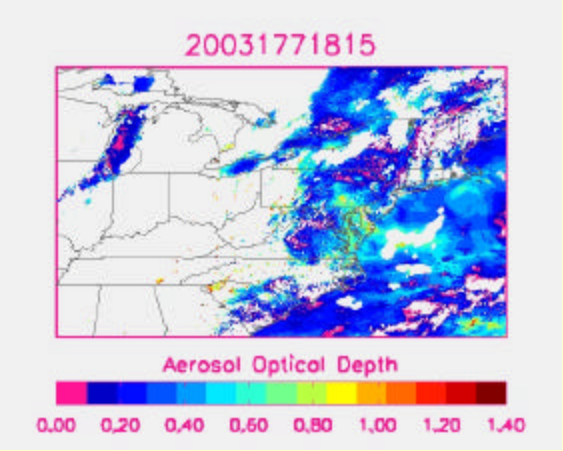
GOES Aerosol and Smoke Product (GASP)

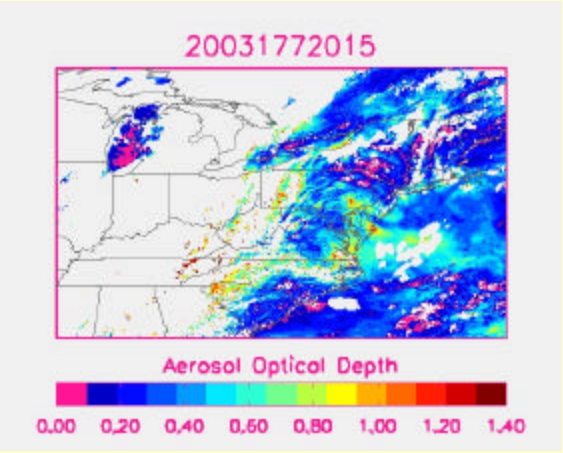
Aerosol optical depths over US at high spatial (4 km) and temporal (30 min.) resolution.

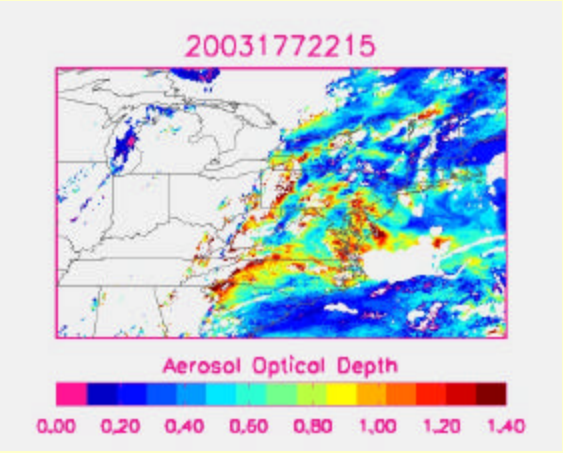


- Surface contribution – Obtained by searching for the second darkest pixel in the last 28 days
- Atmospheric contribution – Removed by parameterizing Rayleigh scattering and gaseous absorption
- Clouds – Masked using spectral differencing technique developed by Stowe et al., J. of Atmos. and Ocea. Tech., 1999
- Aerosol retrieval – Pre-computed look-up tables as a function of surface reflectance, illumination & viewing geometry, and aerosol optical properties

For algorithm details see Knapp, JGR, 2002

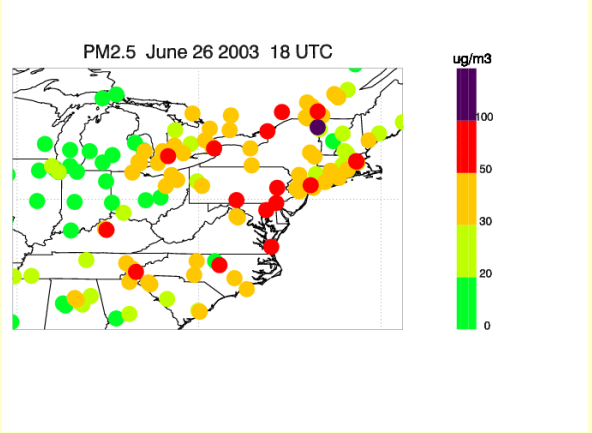


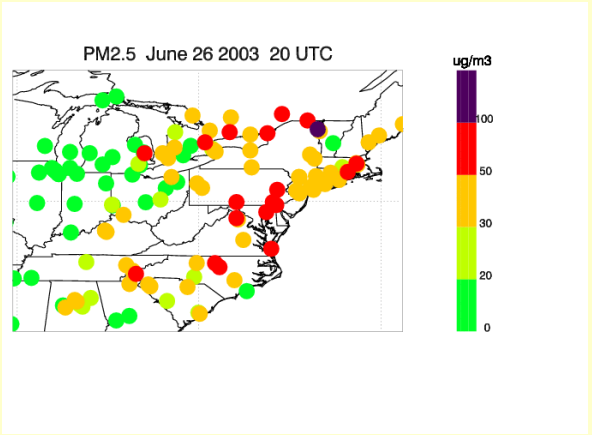


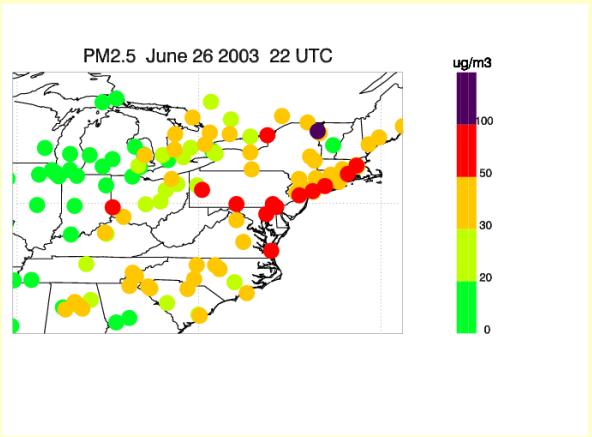


Both GOES AOD and PM2.5 show pollution to be spatially and temporally variable

- **GOES AOD intensifies progressively over MD/DE region while PM2.5 remain high**
- **GOES AOD low over NY region while PM2.5 high**

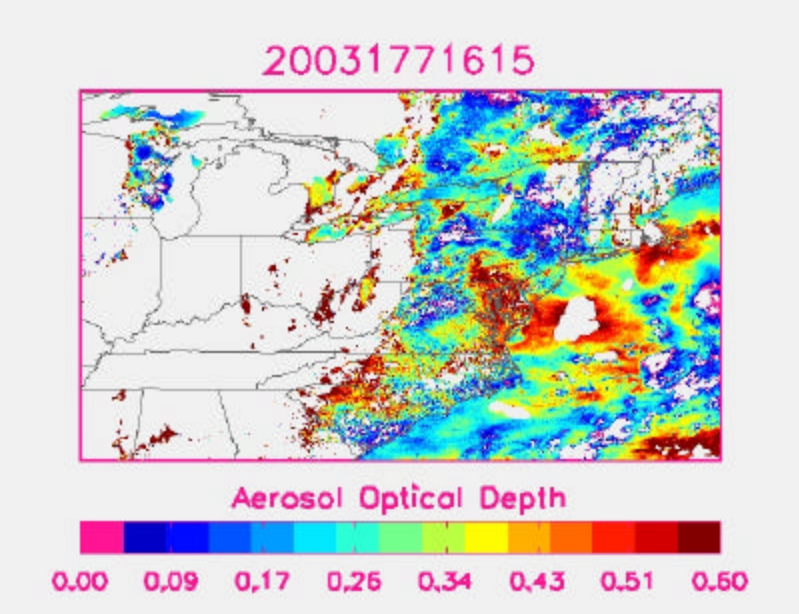




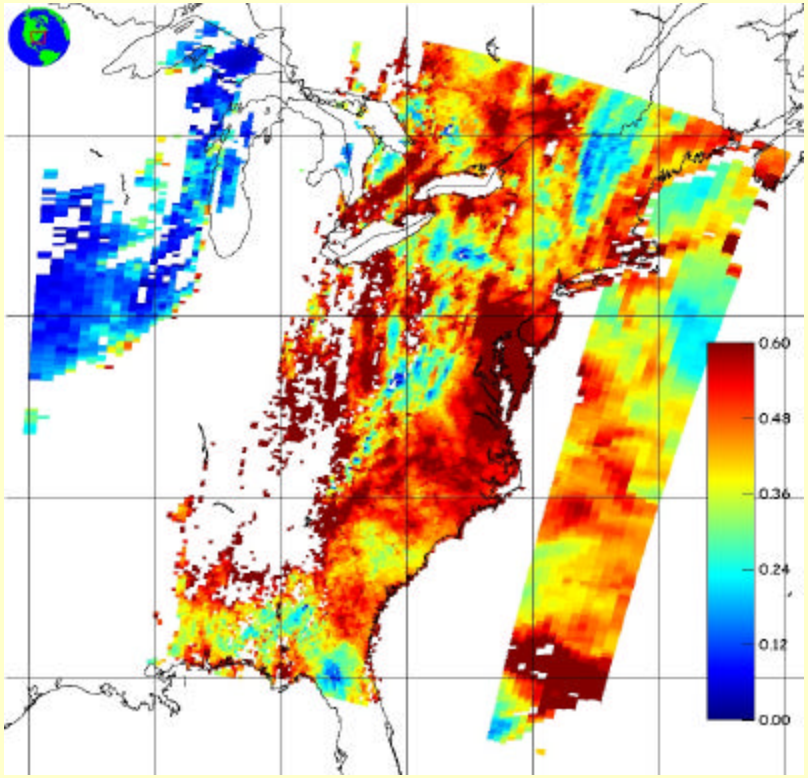


Comparison of GOES and MODIS AOD

GOES 1615



MODIS (Aqua) 1620



Sources of retrieval differences under evaluation.

Robert Levy, NASA/UMD, Personal Communication

Summary

- **We are operational, 24/7.**
- **We are located in Camp Springs MD.**
  - **Come by for a visit!**
- **We are interested in making our products better suit your needs.**

Additional acknowledgements:
• ORA – Bruce Ramsay
• RSIS – Tim Kasheta, Jason Taylor, Tad Franson, Andy Watson, Jerry Guo
• IMSG – Tom Callsen
• SSD – Davida Street, Jamie Kibler, John Simko, Greg Gallina, Marlene Patterson